A COMPARISON

OF

CATCH BASIN

INLET GRATE EFFICIENCIES

THE ONTARIO WATER RESOURCES COMMISSION

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By:

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SUMMARY

A study to determine the relative efficiencies of six catch basin inlet grates has been conducted by the Division of Research, Ontario Water Resources Commission.

The evaluation was carried out in the OWRC laboratory on a wooden gutter, using river water. No attempt was made to duplicate field conditions and thus it was the relative efficiencies rather than the actual field efficiencies which were determined.

The catch basin inlet grates studied were found to be in the following decreasing order of efficiency: Rowland grate, Michigan grate, New York grate, DHO-SD-7-74 modified grate, DHO-SD-7-74 standard grate and DHO-DD-706 grate.

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INTRODUCTION

At the request of the Department of Highways of
Ontario, and with Commission approval, the Division of
Research of the Ontario Water Resources Commission undertook
a study to compare the relative efficiencies of various
catch basin inlet grates.

The evaluation was carried out in the OWRC
laboratory on a wooden gutter using the actual grates in all
cases but one, when a full scale wooden model was used. No
attempt was made, in this study, to duplicate field conditions.
Thus, it was the relative efficiencies rather than the actual
field efficiencies which were being compared.

Five catch basin grates were evaluated in the
study: the Rowland grate, the Michigan grate, DHO-SD-7-74
modified, DHO-SD-7-74 standard and the DHO-DD-706 grates.
The relative efficiencies were determined to be in the same
decreasing order as above.

THEORETICAL CONSIDERATIONS

The efficiency of a grate will be influenced by the velocity of flow, relative length of grate (length/width), relative depth of flow (depth of flow/width of grate), the cross-fall, the longitudinal grade, the geometric configuration of the grate and the rate of flow.

Since all grates were of almost equal length and width the relative length of grate and the relative depth of flow were eliminated as variables in this study. Both factors, however, do play important roles in determining the percentage of water a grate will intercept.

The efficiency of the grate would be expected to decrease with increasing velocity of approaching flow. At a given depth, the faster the flow, the greater will be the tendency for water to by-pass or to "jump over" the grate. The actual effect of velocity, however, is largely dependent upon the geometric configuration of the grate. Those with straight bars or vanes running parallel to the flow will allow more water to pass at higher velocities than those with vanes in such positions that any flow across the face of the grate is broken.

The percentage cross-fall of the gutter is important in determining the amount of water which by-passes the grate. Geometric configuration also plays an important role in this respect in determining the efficiency of the grate in intercepting side flow into the grate. At given flows, it would be expected that a given grate will have a higher efficiency at a high cross-fall than a low one, especially at high flows, since the lateral spread of flow is decreased. Grates without curb openings may realize an opposite effect of cross-fall, however, depending again upon the geometry of the grate. Water may tend to "pile-up" at the curb and flow over any straight wide bars.

The longitudinal grade of the gutter is important in determining the velocity of flow. The higher the grade, the higher the velocity and thus, one would expect, the lower the efficiency of the grate. Such, however, is not always the case; again the geometry of the grate is the deciding factor in this regard.

The rate of flow determines the amount of water passing down the gutter. This effects its velocity, its head over the grate and the tendency of water to by-pass the grate. Again the efficiency would be expected to decrease with increasing flow, but the rate of decrease depends again upon the geometry of the grate.

EXPERIMENTAL APPARATUS AND PROCEDURE

For this study, a model gutter 32 ft long by
4 ft wide was constructed. The upstream end of the gutter
was fitted with a tank to which water was supplied at
predetermined flow rates. The grates were installed 24 ft
from the upstream end of the gutter. A screened baffle
located immediately below the head tank allowed the approach-
ing flow sufficient opportunity to acquire a uniform state
before reaching the inlet. Figures 1 and 2 present views
of the model gutter.

The gutter was constructed of 3/4 in. plywood
sheets held together by 2 in. x 6 in. planks which also
acted as gutter walls. The gutter was supported upon four
trestles. The longitudinal grade and cross-fall could be
set at predetermined positions by means of sets of wedges,
such that the gutter remained supported on each trestle
preventing any warping.

The catch basin grate under study was situated
immediately above a drain in the laboratory floor. Any flow
through the grate was discarded while by-passed flow was
volumetrically measured and recorded. Thus, by knowing
the total influent and the by-passed flow, the efficiency
of the grate could be determined.

Four flow rates were used in the study: 88 gpm, 150 gpm, 238 gpm and 288 gpm. Using the Rational Formula these flows correspond to the runoff from a 200 ft x 26 ft section of pavement at rainfall intensities of 1.98 in./hr, 3.36 in./hr, 5.34 in./hr and 6.46 in./hr, respectively.

Cross-falls of 2% and 6%, and longitudinal grades of 0.4%, 2%, 4% and 6% were studied.

A baffle running the length of the gutter was included in all tests to prevent lateral spread at high flows. Thus a greater head on the grate, both from upstream and from the side, was obtained.
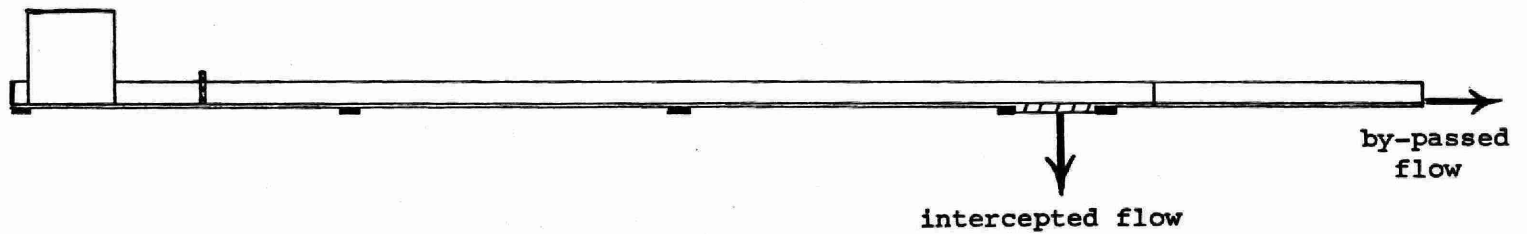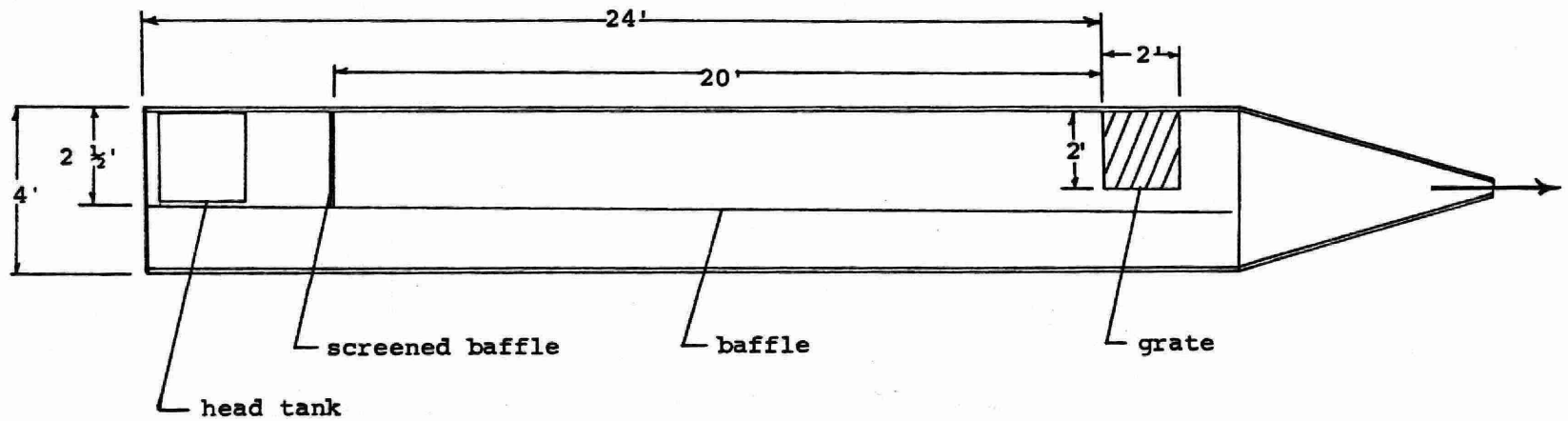
PLAN VIEW

by-passed flow

intercepted flow

₵ SECTION

Figure 1 - MODEL GUTTER
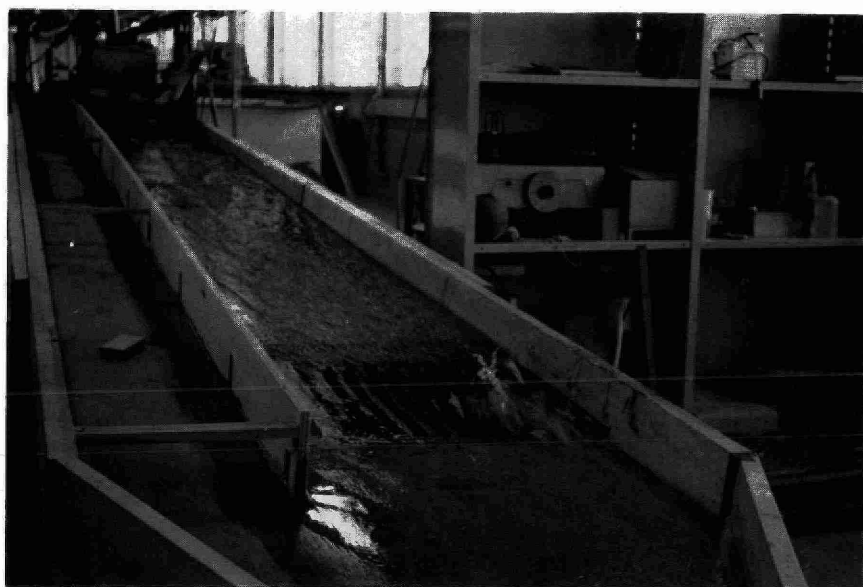
Figure 2 - MODEL GUTTER

DESCRIPTION OF INLET GRATES

1. DHO-DD-706

This is a flat grate constructed of cast iron with straight ribs as shown in Figure 3. This grate is positioned next to the curb but with no curb opening.

2. DHO-SD-7-74 Standard

This is a depressed grate constructed of cast iron with straight ribs as shown in Figure 4. It is positioned next to the curb opening in an undepressed gutter.

3. DHO-SD-7-74 Modified

This is the same grate as the standard SD-7-74, but for purposes of comparison in this study all vane openings of the grate were rounded. It is shown in Figure 5.

4. Michigan

This is a flat grate of cast iron with waved ribs as shown in Figure 6. This grate is also positioned next to the curb opening.

5. Rowland

This is also a flat grate but the openings are constructed of specially designed rounded vanes running

diagonal to the flow. This grate is shown in Figure 7. A
curb opening is also used with this grate. The Rowland grate
evaluated in this study was a full scale wooden model.
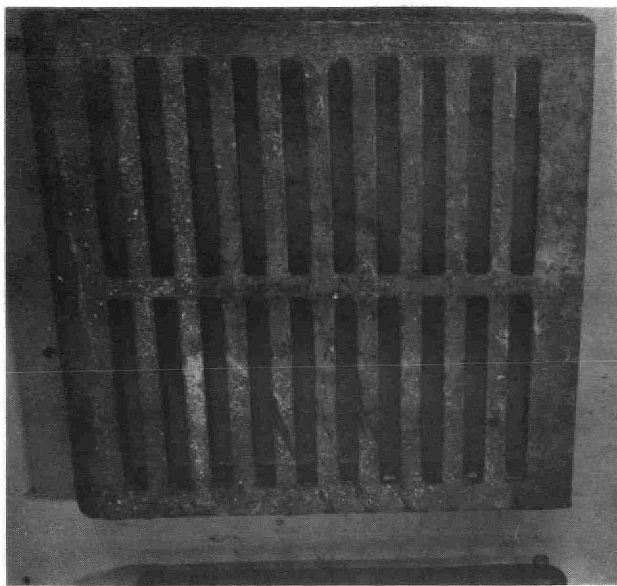
Figure 3 - DHO-DD-706

Figure 4 - DHO-SD-7-74
Standard
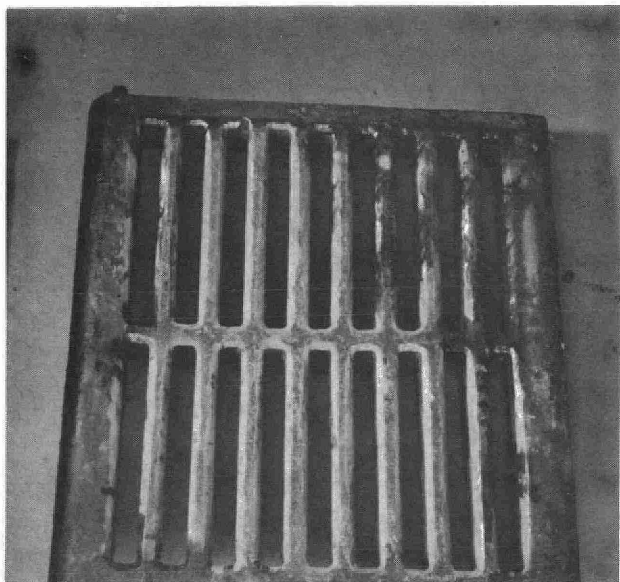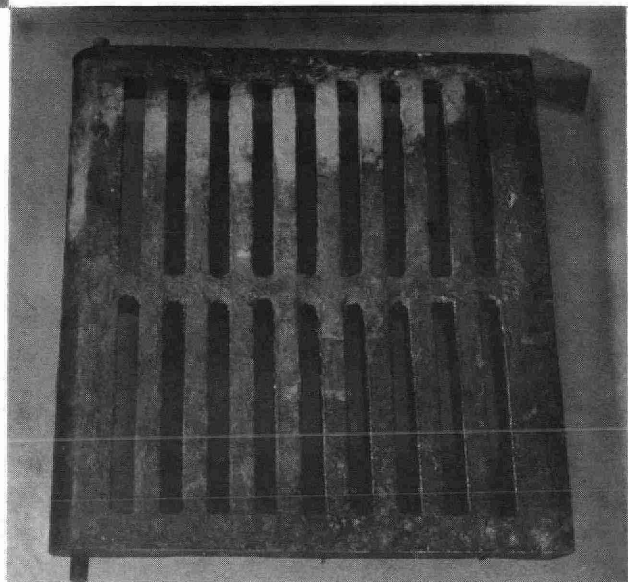
Figure 5 - DHO-SD-7-74
Modified

Figure 6 - Michigan
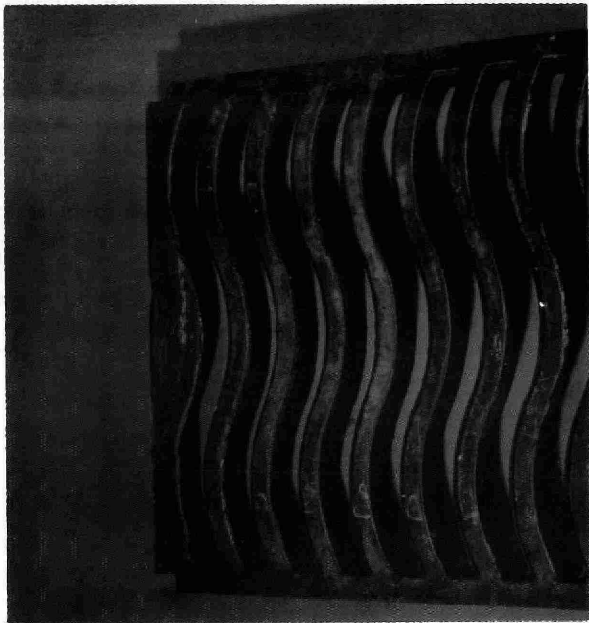
Figure 7 - Rowland

TEST RESULTS

Test results indicate the grates to act in the following order of decreasing efficiency: Rowland grate, Michigan grate, DHO-SD-7-74 modified, DHO-SD-7-74 standard and DHO-DD-706. However, as can be noted from Table 1 under the flow and slope conditions studied, all efficiencies obtained were above 80%. Thus, the difference in efficiency between the best and the worst grate may not be as great as that first surmised on comparing Figures 8 and 9.

Figure 8 presents a plot of efficiency vs longitudinal grade for each grate at given flows and cross-falls. Figure 9 compares plots of efficiency vs flow of each of the grates at given longitudinal slope and cross-fall.

From Figures 8 and 9 it may be seen that the Rowland grate maintained the highest efficiency of all grates under all conditions studied. The Michigan grate was a close second, the greatest efficiency difference between the two being in the order of 2.5% at a longitudinal grade and a cross-fall each of 2%.

The modified DHO-SD-7-74 grate was somewhat higher in efficiency than its prototype at low flows. However, at

combinations of higher flows and the 6% cross-fall its

efficiency dropped off at a greater rate than the standard

DHO-SD-7-74 grate.

The DHO-DD-706 grate was the least efficient of

all grates studied except at a cross-fall of 2% and longitudinal

grade of 0.4% at which time it was slightly more efficient

than both the DHO-SD-7-74 grates.

TABLE 1 (KEY)

Q = inflow (Imperial gallons)

C_s = Cross-fall

L_s = Longitudinal grade

(1) = DHO-DD-706

(2) = DHO-SD-7-74 (standard)

(3) = DHO-SD-7-74 (modified)

(4) = Michigan

(5) = Rowland

TABLE 1

Q (gpm)	C_S (%)	L_S (%)	Efficiency - (%)				
			(1)	(2)	(3)	(4)	(5)
88	2.0	0.4	98	98	98	99	98
150			95	92	93	96	97
238			93	90	90	95	96
288			92	90	90	95	96
88	2.0	2.0	97	98	100	96	99
150			92	94	95	95	97
238			88	90	90	93	95
288			86	88	90	93	95
88	2.0	4.0	96	97	99	98	99
150			90	92	94	97	97
238			86	89	92	95	96
288			85	88	91	94	95
88	2.0	6.0	93	96	99	99	100
150			88	91	95	96	97
238			83	87	90	95	95
288			81	85	89	94	94
88	6.0	0.4	99	100	100	100	100
150			98	100	100	100	100
238			98	98	99	99	99
288			97	98	98	99	99
88	6.0	2.0	97	99	100	100	100
150			96	99	100	99	100
238			96	98	100	99	100
288			96	98	99	99	100
88	6.0	4.0	93	98	100	100	100
150			92	97	98	99	100
238			92	95	95	99	100
288			91	94	94	99	100
88	6.0	6.0	92	97	99	99	100
150			94	94	94	99	100
238			83	92	90	99	100
288			82	90	88	99	100
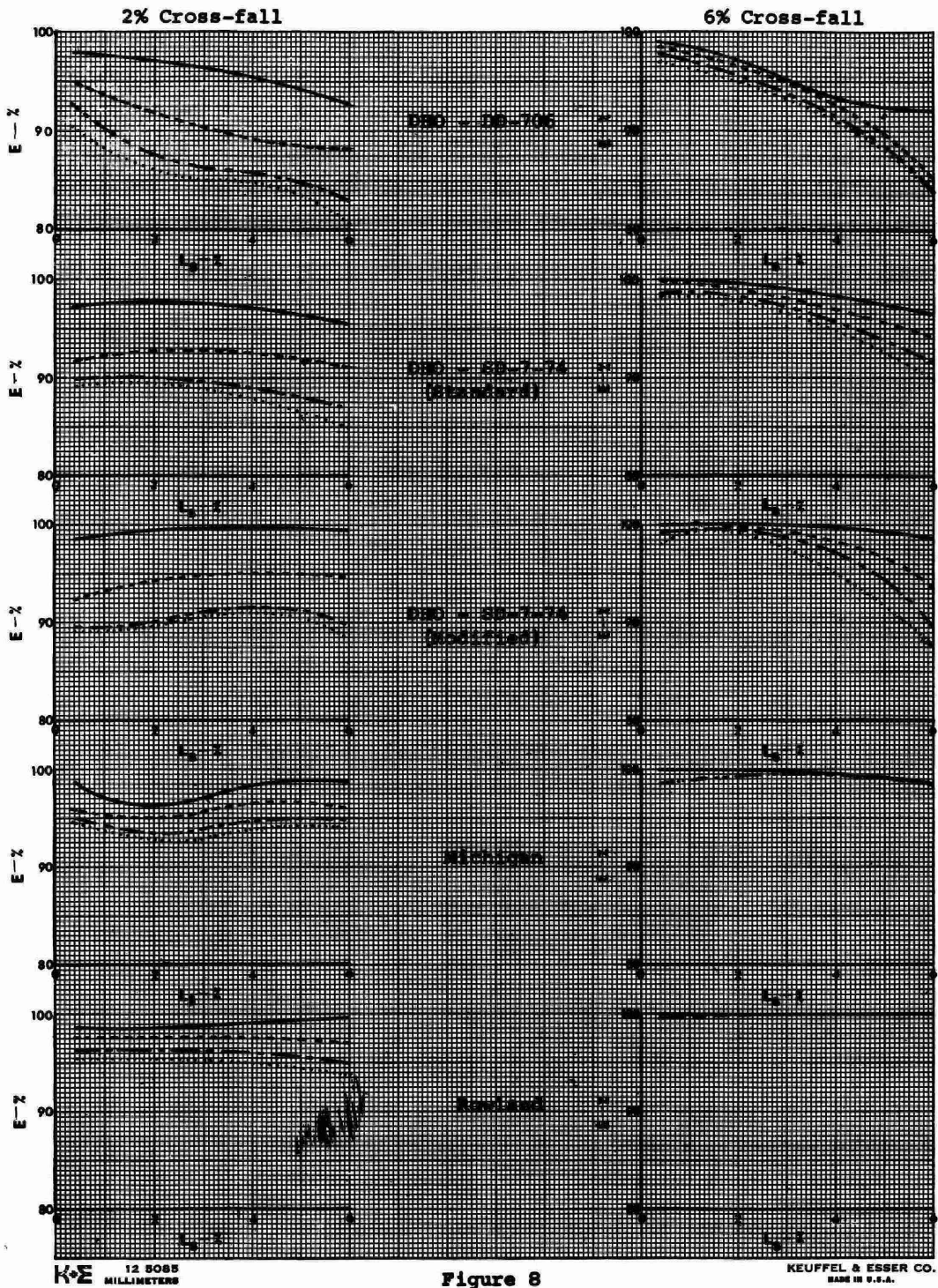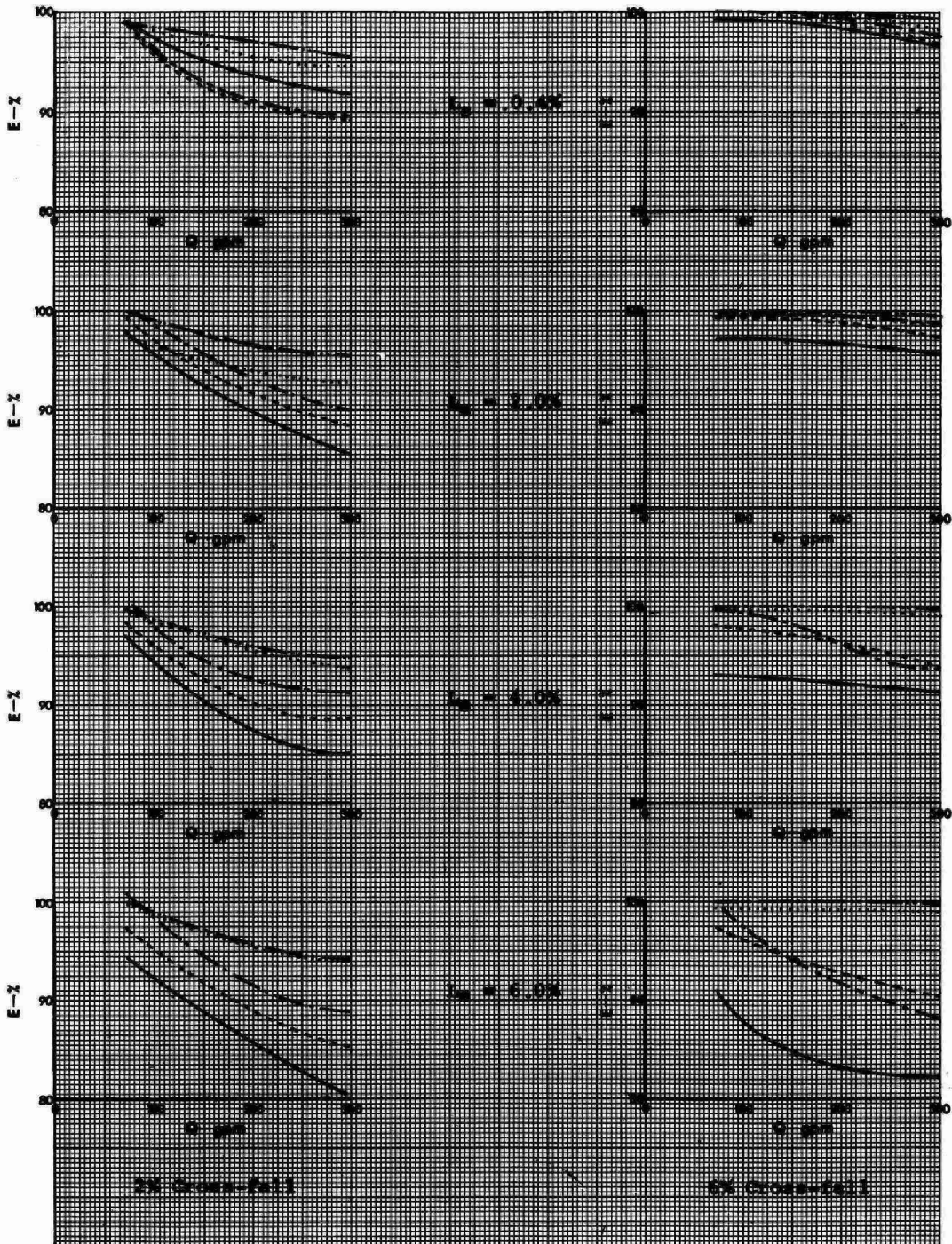
Figure 8

Figure 9

DISCUSSION

By considering the geometric configuration of each grate one could generally arrive at the order of efficiencies of the various grates. The DHO-DD-706 and DHO-SD-7-74 grates have straight bars running the length of the grate and parallel to the flow. Each of these grates would be expected to exhibit lower efficiencies than the Michigan and Rowland grates which will not allow the water to pass smoothly over any part of the surface of the grate. The DHO-DD-706 grate is mounted with no curb opening, while all the other grates are. Thus the combination of straight bars and no curb opening would place this grate as the least efficient under the full range of flow conditions. The DHO-SD-7-74 grate is also slightly depressed.

The modified DHO-SD-7-74 grate would be expected to exhibit higher efficiencies than the standard. This was so in all cases except those of high slopes and flows.

The Michigan and Rowland grates, since neither allows straight passage of flow over the surface, would be expected to be of nearly equal efficiency, and the efficiency would approach 100% provided flow conditions were such as to allow no complete by-passing of the grate.

Hydraulic efficiency of a grate is continuously obtainable only if that grate remains at least relatively free of debris accumulation. Thus, although a certain geometric configuration of one grate may give it a higher hydraulic efficiency than any other grate, it may also allow the grate to become clogged with floating debris. Although this study was designed to investigate flow characteristics under conditions free of debris, a study to determine the self-cleaning characteristics of these grates would be desirable before placing such grates in situations where leaves and other debris are likely to accumulate.

CONCLUSIONS

Based on the results of an hydraulic efficiency study of catch basin inlet grates, the five grates studied are placed in the following order of decreasing relative efficiency: Rowland grate, Michigan grate, DHO-SD-7-74 modified grate, DHO-SD-7-74 standard grate and the DHO-DD-706 grate.

The difference in efficiencies between the Rowland and the Michigan grates is negligible except perhaps at a cross-fall and a longitudinal grade each of 2%, at which time the geometric configuration of the Michigan grate effects a slight reduction in its efficiency.

APPENDIX

Shortly after completion of the foregoing study a sixth grate, the New York grate, was received. Since the original gutter was still available a set of runs at the same grades and cross-falls as before were carried out on this grate.

The New York grate is of welded steel construction as shown in Figure 10. The openings of the grate are approximately 2" in width with dividing members of 1/4" x 2 1/2" steel plate. Longitudinally the openings of the grate are divided approximately every 4 inches by 1/4" x 3/4" plates.

Upon looking at the grate, one would expect it to be very efficient over a wide range of conditions since the openings are very large in relation to the thickness of material used. The vanes or dividers are not thick enough to allow water to run along them and over the grate. The cross members may, however, cause some obstruction to flow at high velocities.

Plots of efficiency vs flow rate and of efficiency vs longitudinal grade are presented in Figures 11 and 12, respectively, for the trial runs. The curves of Figure 11 have been projected and are thus only estimates of efficiency beyond the flows studied.
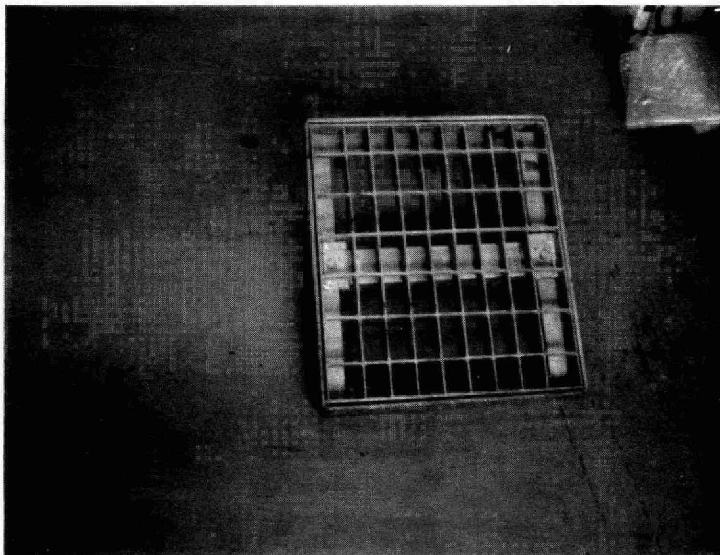
Figure 10 - New York Grate

Figure 11 indicates that at a cross-fall of 2% the efficiency was fairly constant at 97 and 99%. Any loss of efficiency here was due to flow by-passing the grate at the low cross-fall. At the 6% cross-fall the efficiency decreased quite rapidly as the velocity and quantity of approaching flow increased. At low longitudinal grades, the grate exhibited efficiencies of 100%, however, as the grade increased to 4 and 6%, the efficiency dropped off rapidly with increasing flow. The observed reason for this was that the flow through the grade was obstructed by the 3/4" cross members, causing the flow to jump from cross member to cross member over the grate. At high velocities this effect was highly noticeable.

Comparing the efficiency of this grate with the other grates studied, its relative efficiency would appear to lie somewhere in between the Michigan and the DHO-SD-7-74 Modified grates. At low flow velocities its efficiency appears comparable to that of the Rowland grate but as has been stated this high efficiency rapidly declines as flow velocities are increased.

Perhaps a slight modification in design of the grate cross members would increase this grate's efficiency to that of the Rowland grate.

Figure 11

New York Grate

Key

E = efficiency

L_s = longitudinal grade

Q = inflow (imperial gallons)

———— L_s = 0.4%

------ L_s = 2.0%

—·— L_s = 4.0%

—··— L_s = 6.0%

Figure 12

New York Grate

Key

E = efficiency

L_s = longitudinal grade
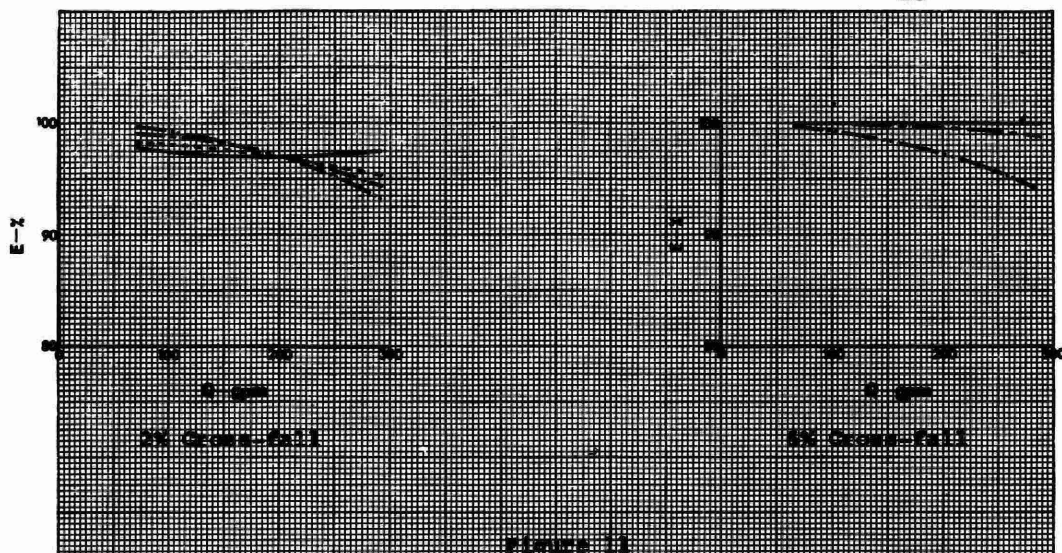
Q = inflow (imperial gallons)
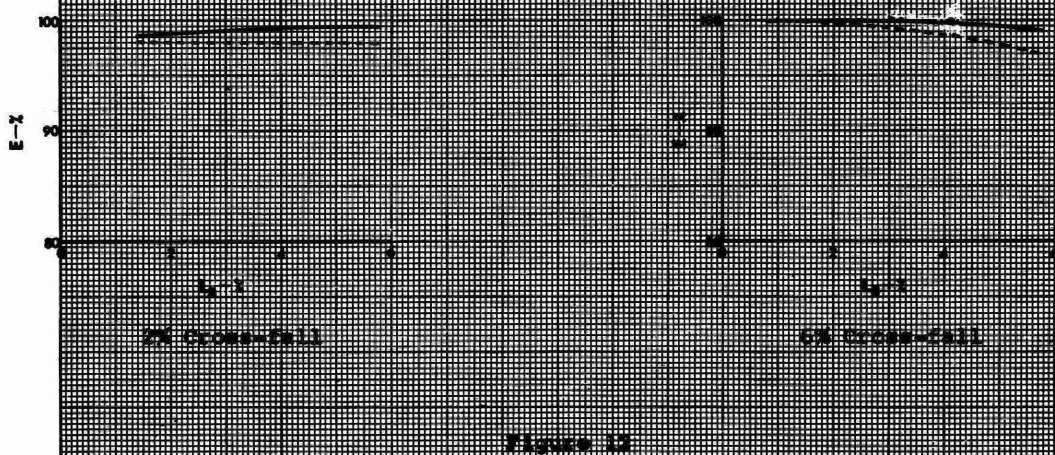
———— Q = 150 gpm

----- Q = 200 gpm

Figure 11

Figure 12

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